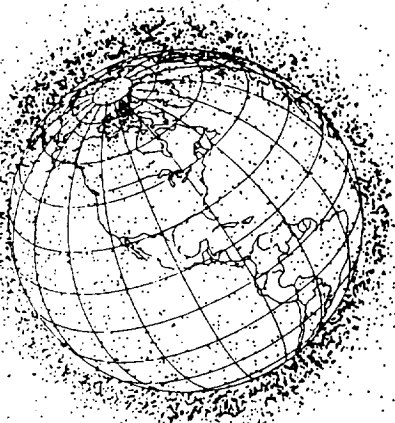


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## ORBITAL DEBRIS REMOVAL AND SALVAGE SYSTEM

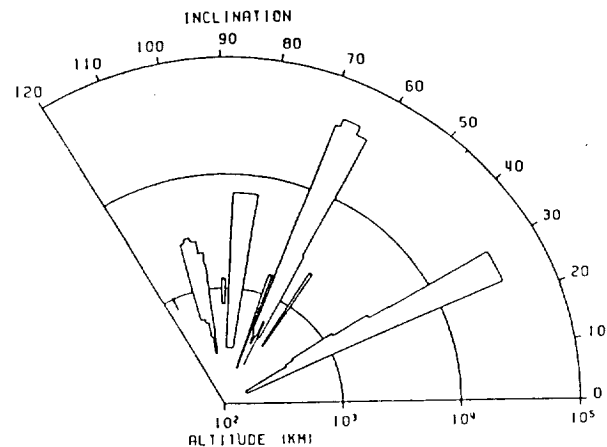


"Birds-Eye" View of Near-Earth Satellites

The near-Earth environment is becoming increasingly hazardous. There are at least 10,000 known debris objects in orbit that are larger than 4 cm in diameter and the number of objects smaller than 4 cm is expected to be even greater. The situation has become so desperate that a critical part of satellite design is protection from debris. One instance of damage from debris collision was a 1-cm pit in the window of the space shuttle caused by a 0.2-mm fragment of paint. It is estimated that the Hubble Space Telescope has a 1% chance of being destroyed by a collision during its lifetime. The probability of satellite destruction will continue to increase as more and more launches are performed annually. At this point in time, the danger is not large enough to necessitate countermeasures. However, by the early- to mid-twenty-first century, countermeasures will be imperative.

The purpose of this design is to eliminate a majority of the orbital debris. The Orbital Debris Removal and Salvage System (ODRASS) will push the smaller particles into lower orbits where their orbits will decay at a higher rate. This will be done with momentum transfer via a laser. The salvageable satellites will be delivered to the Space Station by an Orbital Transfer Vehicle. The rest of the debris will be collected by Salvage I. This will provide an active means of orbital debris management.

**Acknowledgments.** Project Team Members were Todd Shelton, Doug Cramer, and Matt Dougherty



Orbital Debris Distribution as a Function of Altitude and Orbital Inclination

### DESIGN OF A SPACE-BASED SATELLITE SYSTEM TO PREVENT THE DEPLETION OF ATMOSPHERIC OZONE/OPI-e

The first purpose of this design is to attack one of the many problems facing the environment and explore a possible solution. Our design group has chosen to focus on the problem of ozone depletion in the Antarctic. We propose using a space-based system to interact with the stratospheric region over the Antarctic. This task will be accomplished by using an orbiting solar array system designed to transmit microwaves at a frequency of 22 GHz over the region in order to dissipate polar stratospheric clouds (PSC) that form during the months beginning in August and ending in October. The solar array system will be driven by a satellite system in a polar orbit at an altitude of 1000 km (621.4 mi). This altitude corresponds to an orbital period of 105.0 minutes. At an altitude of 1000 km, the solar satellite system will be able to beam microwaves into the PSC for 32.7 minutes every orbit. We have determined that the amount of microwave energy necessary to dissipate the PSC is approximately  $3.44 \times 10^{16}$  J. We have calculated that a PSC can be dissipated in approximately 38.8 days by a system incorporating two microwave emitting satellites inputting  $5 \times 10^{15}$  J every 32.7 minutes every orbit. Each satellite will collect energy using a system incorporating solar cells in conjunction with storage batteries for nine months of the year. The energy will be transferred to flywheels that will be sized to discharge energy at a rate of 25.5 GW/orbit for the required three-month period.

The second purpose of this environmental intervention design study is to provide a fundamental understanding of the chemistry of ozone depletion over the Antarctic. We hope that

Results of Hurricane Seeding Experiment

Hurricane	Dates	Number of seedings	AgI used (kg)	Maximum wind change (%)
Unnamed	13 Oct 1947	1	Unknown	Unknown
Esther	16 Sep 1961	1	35	-10
Esther	17 Sep 1961	1	35	0*
Beulah	23 Aug 1963	1	220	0*
Beulah	24 Aug 1963	1	335	-14
Debbie	18 Aug 1969	5	185	-30
Debbie	20 Aug 1969	186	-15*	
Ginger	26 Sep 1971	2	7	0†
Ginger	28 Sep 1971	3	96	decrease†

\* Suitable clouds not seeded

† Large old decaying storm with few seedable clouds

the ideas presented within our paper will spark creative new ideas. It is also our hope that our work will encourage others to look more closely into the problems facing our world. We hope to promote an awareness of the problems mankind has bequeathed to future inhabitants of the planet Earth.

#### PROJECT POSEIDON: A CONCEPTUAL DESIGN OF A SPACE-BASED HURRICANE CONTROL SYSTEM

Project Poseidon is a conceptual design for a space-based hurricane control system. The project was undertaken in response to an initiative from Lyle M. Jenkins of the Johnson Space Center on the topic of environmental intervention from space. Project Poseidon consists of a network of 21 low-orbiting laser platforms arranged in three rings designed to heat the upper atmosphere of a developing tropical depression. Fusion power plants are proposed to provide power to the lasers. The necessary tracking information will be provided by existing weather satellites and ground stations. Cooling for the optics and electronic components will be provided by sorption refrigeration. The target launch date for the proposed network is 2025 to 2050. Necessary assumptions were made in the conceptual design phase on the achievable technology level by this time period.

**Acknowledgments.** Project Members were Kyle Cooper, Jorge Frank, and Michael Kalinowski.

Reduction in Destructive Force with Respect to Wind Speed

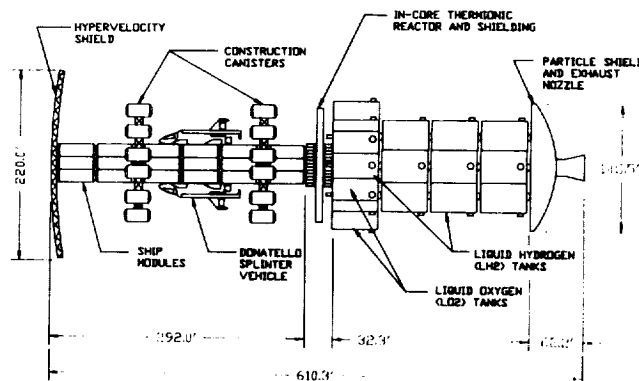
Reduction in wind speed (%)	Reduction in destructive force (%)
10	27
20	49
30	66
40	78

#### PROJECT DONATELLO: A PROPOSED MARS EXPLORATION INITIATIVE FOR THE YEAR 2050

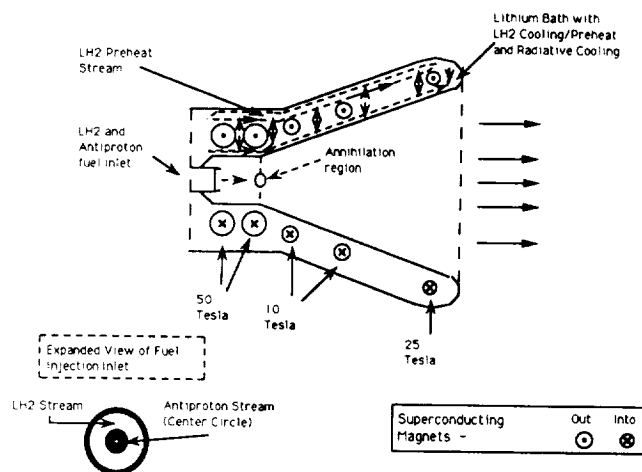
This project is a conceptual design for a futuristic superfreighter that will transport large numbers of people and supplies to Mars for the construction of a full-scale scientific and manufacturing complex. Code named "Project Donatello,"

the freighter will be assembled at the first libration point (L1) of the Earth-Moon system. The ship will be constructed with materials supplied by Heavy Lift Launch Vehicles (HLLVs) from Earth and from Orbital Transfer Vehicles (OTVs) from the large lunar base.

Donatello will utilize an antimatter propulsion system that will drastically reduce Mars trip time and the fuel mass



Donatello: Superfreighter to Mars



Anti-proton/Liquid Hydrogen Annihilation Propulsion Engine (A/LH-APE)

requirements of the ship. Upon arrival at Mars, two smaller transfer ships will carry railroad boxcar sized payload canisters into the martian atmosphere and to the vicinity of the existing Mars outpost. The canisters will be parachuted to the surface allowing the transfer ships to make numerous runs with low fuel consumption. The vehicles will also have vertical takeoff and landing (VTOL) capabilities when transporting fuselage canisters containing the Mars base personnel.

The canisters will contain construction materials for an advanced Mars base, including material processing components, airshells, life support systems, power supplies, scientific and industrial equipment, and food production systems.

**Acknowledgments.** Project Members were John G. Vandegrift, Kenneth, E. Brunsen, Timothy F. Dawn, and Brian H. Kendall.

